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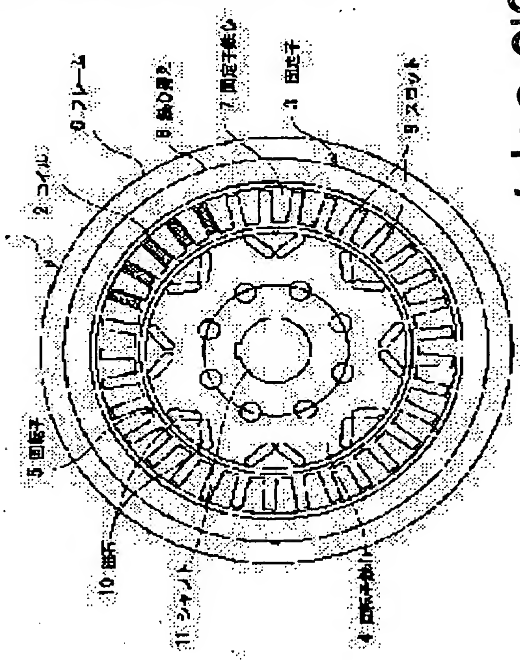
(54) SYNCHRONOUS ROTATING MACHINE AND PERMANENT-MAGNET RELUCTANCE MOTOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a synchronous rotating machine, having the combination of a number of poles and a number of slots suitable for reducing vibration and slot ripples.
SOLUTION: The rotating machine is provided with a stator 3, including armature coils 2, a cylindrical rotor 5 composed of a rotor core 4 that forms magnetic irregularities, and permanent magnets 10 housed in all or some of slits arranged in the direction of the magnetic pole axes of the rotor. The magnetic poles are set so that the number of slots for each pole and for each phase is a fraction and the combination of the number of poles and the number of slots is set so that the order of vibration mode is low, and electromagnetic force is not produced. Examples of suitable combinations include a combination of eight poles in the rotor and 12, 36, or 60 slots in the stator, a combination of 10 poles and 15 or 45 slots, a combination of 12 poles and 18 or 54 slots, a combination of 14 poles and 21 or 63 slots, and a combination of 16 poles and 24, 36, 60, or 72 slots.



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CLAIMS

[Claim(s)]
[Claim 1] The synchronous rotating machine characterized by having set the pole into eight poles and setting the number of slots to 12, 36, or 60 so that an armature coil may be stored in the slot of an armature core and the oscillation mode of a low degree may not generate [**** and the number of **** slots] the combination of a pole and the number of slots by the fraction in the synchronous rotating machine which opposes a field.
[Claim 2] The synchronous rotating machine according to claim 1 characterized by having set said pole into ten poles and setting said number of slots to 15 or 45.
[Claim 3] The synchronous rotating machine according to claim 1 with which the pole of said rotator is characterized by 12 poles and the number of slots of said stator being 18 or 54.
[Claim 4] The synchronous rotating machine according to claim 1 characterized by having set said pole into 14 poles and setting said number of slots to 21 or 63.
[Claim 5] The synchronous rotating machine according to claim 1 characterized by having set said pole into 16 poles and setting said number of slots to 24, 36, 60, or 72.
[Claim 6] the slot arranged at each magnetic pole shaft orientations of the stator which has an armature coil, the rotator of the shape of a cylinder constituted by the rotor core which forms magnetic irregularity, and this rotator -- or the synchronous rotating machine according to claim 1 to 5 characterized by having the permanent magnet held in that part, and operating as a permanent-magnet type reluctance motor.
[Claim 7] The stator which has an armature coil, and the rotator of the shape of a cylinder constituted by the rotor core which forms magnetic irregularity, the slit arranged in the direction in alignment with each magnetic pole shaft of said rotator -- or the combination of a predetermined pole and the number of slots by the fraction, although the number of slots for which is equipped with the permanent magnet held in a part of slit, and it is sufficient by **** and ** generates the momentary electromagnetic force of the oscillation mode of a low degree It is the permanent-magnet type reluctance motor set as what does not take out degree harmonic content. carrying out a sequential rotation -- balancing -- average -- low -- The permanent-magnet type reluctance motor with which the pole of said rotator is characterized by four poles and the number of slots of said stator being 18, 30, 42, 54, or 66.
[Claim 8] The permanent-magnet type reluctance motor according to claim 7 with which the pole of said rotator is characterized by six poles and the number of slots of said stator being 27, 45, or 63.
[Claim 9] The permanent-magnet type reluctance motor according to claim 7 with which the pole of said rotator is characterized by 12 poles and the number of slots of said stator being 27, 45, or 63.
[Claim 10] The stator which has an armature coil, and the rotator of the shape of a cylinder constituted by the rotor core which forms magnetic irregularity, the slit arranged in the direction in alignment with each magnetic pole shaft of said rotator -- or the combination of a predetermined pole and the number of slots by the fraction, although the number of slots for which is equipped with the permanent magnet held in a part of slit, and it is sufficient by **** and ** generates the momentary electromagnetic force of the oscillation mode of a low degree It is the permanent-magnet type reluctance motor which set the secondary harmonic content which balances and affects an oscillation most by carrying out a sequential rotation as what is not taken out on the average. The permanent-magnet type reluctance motor with which the pole of said rotator is characterized by eight poles and the number of slots of said stator being 18, 42, or 54.
[Claim 11] The permanent-magnet type reluctance motor according to claim 10 with which the pole of said rotator is characterized by ten poles and the number of slots of said stator being 12, 18, 42, 48, 54, 66, or 72.
[Claim 12] The permanent-magnet type reluctance motor according to claim 10 with which the pole of said rotator is characterized by 14 poles and the number of slots of said stator being 24, 30, 36, 48, 54, 60, or 72.
[Claim 13] The permanent-magnet type reluctance motor according to claim 10 with which the pole of said rotator is characterized by 16 poles and the number of slots of said stator being 30, 42, 54, or 66.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a synchronous rotating machine and a permanent-magnet type reluctance motor.
[0002]
[Description of the Prior Art] The permanent-magnet type reluctance motor belonging to a synchronous rotating machine is constituted by the stator which generally has an armature coil, and the rotator rotated in a stator. And the rotator is approximately cylindrical, and the coil which forms a field is not prepared in it, but the magnetic concavo-convex section is formed in the circumferencial direction. the slit by which the magnetic irregularity of the circumferencial direction of this rotator is arranged in the direction in alignment with each magnetic pole shaft of a rotator -- or it is formed by holding a permanent magnet in a part of slit.
[0003] Such a permanent-magnet type reluctance motor of structure has the features which structure can be easy and can be cheaply manufactured as compared with the induction motor currently widely used for the electric car from the former.
[0004] Moreover, in the induction motor, since loss also with comparable rotator and stator is generated, incorporated air from the exterior for the cooling, it was made to go via the exoergic section, and the air-cooling method breathed out outside again has been adopted. However, in order to incorporate the air containing many dust of the motor circumference inside a motor in the case of an air-cooling method, dust accumulates on the path of the cooling style, and it comes to bar ventilation. Therefore, in order to keep the motor engine performance constant for a long time, a customer engineer is forced periodical clearance of this dust.
[0005] On the other hand, since there is almost no loss of a rotator in the case of a permanent-magnet type reluctance motor, the close-by-pass-bulb-completely natural-air-cooling method which it was halved, and the amount of the air which needs only the part for cooling ended at least, and lost incorporation of air thoroughly is also possible for the loss generated inside a motor.
[0006] If a permanent-magnet type reluctance motor is used for an electric car from this field, as compared with the system using the conventional self-ventilation type induction motor, it will become what was excellent also from on the maintenance also from the field of a price.
[0007] On the other hand, since a permanent-magnet type reluctance motor generates reluctance torque in a slot location and the location of the magnetic heights of a rotator in order to use a magnetic saliency, this torque influences the frame of a motor as a reaction, and it is said for a shimmy and a slot ripple to occur. In addition to an oscillation, with the noise, a slot ripple appears as harmonic content of cogging torque or induced voltage, and a shimmy becomes the cause of worsening the engine performance.
[0008] If it is in AC servomotor increasingly used as a driving gear of a robot or a machine tool in recent years, the little of a revolution ripple or a torque ripple serves as an important element. Also in the motor in the electric car which thinks pair environment nature as important, the little of a revolution ripple or a torque ripple serves as an important element like this.
[0009] In the case of AC servomotor, a permanent-magnetic motor is in use, but the skew for one slot is given to the armature core as a cure which reduces a slot ripple to this.
[0010]
[Problem(s) to be Solved by the Invention] Although it was effective to have given the skew for one slot in order to reduce a slot ripple in a permanent-magnetic motor as mentioned above, there were the following troubles in this skew.
[0011] In the 1st, the slot inner surface of a layer-built iron core becomes steps-like, slot area decreases, a space factor becomes high, and the workability of armature coil insertion gets worse. Since this coil is inserted in the 2nd in the shape of an involute curve, this also worsens workability. And although it is some, coil length becomes long, and armature ohmic loss increases to the 3rd. In addition, in carrying out the skew of the permanent magnet, it is necessary to prepare many magnet dice, and there is also a trouble that a fabrication is difficult.
[0012] Then, there is the approach of applying the fraction slot for which it is sufficient by **** and ** to the motor of each pole as approach which reduces a slot ripple, without not adopting skew structure and making the number of slots increase too much.
[0013] According to the idea of this fraction slot, the capacity used for the main motor of a rail car made the system of 250kW class as an experiment, and it drove with the inverter of a three-phase-circuit output in recent years. Rotators are [eight poles and the numbers of slots of a stator] 33 slots without a skew in the permanent-magnet type reluctance motor (the 1st prototype) of this prototype. The number of slots for which it is sufficient by **** and ** of this prototype is the fraction slot of 33/(3x8) =1+3/8.
[0014] However, the noise which the oscillation which should be solved occurs and exceeds 100dB lightly generated the result of a pilot run. Then, although it saw even if it raised the reinforcement of a frame, neither an oscillation nor the noise fell.
[0015] In view of such a trouble, an oscillation was not suppressed compulsorily, but when the permanent-magnet type reluctance motor (the 2nd prototype) of this capacity of eight poles and 36 slots is made as an experiment and the same trial is performed from a viewpoint of severing a vibrating agency, the oscillation and noise which had been generated till then have disappeared mostly. The number of slots for which it is sufficient by **** and ** of this 2nd prototype is a fraction slot used as 36/(3x8) =1+1/2.

[0016] I hear that important relation exists between the number of slots, and a pole, and it is in it that I understand from the result of the test of these two prototypes.
[0017] Then, invention-in-this-application persons were able to look for the permanent-magnet type reluctance motor with the combination of the suitable pole and the number of slots which can reduce an oscillation and a slot ripple, and were able to specify the combination of the suitable pole and the number of slots which can reduce an oscillation and a slot ripple in the permanent-magnet type reluctance motor. Therefore, this invention aims at offering a permanent-magnet type reluctance motor with the combination of the suitable pole and the number of slots which can reduce an oscillation and a slot ripple.
[0018] Moreover, since the thought of this invention is widely applicable to a synchronous general rotating machine, this invention aims also at offering a synchronous rotating machine with the combination of the suitable pole and the number of slots which can reduce an oscillation and a slot ripple.
[0019]
[Means for Solving the Problem] In the synchronous rotating machine with which an armature coil is stored in the slot of an armature core, and, as for this invention, opposes a field Or the stator which has an armature coil and the rotator of the shape of a cylinder constituted by the rotor core which forms magnetic irregularity, the slit arranged in the direction in alignment with each magnetic pole shaft of said rotator -- or it has the permanent magnet held in a part of slit, and the number of slots for which it is sufficient by **** and ** by the fraction In the permanent-magnet type reluctance motor which set the combination of a pole and the number of slots as what the electromagnetic force of the oscillation mode of a low degree does not generate, the pole of said rotator is especially characterized by eight poles and the number of slots of said stator being 12, 36, or 60.
[0020] If it is in such a synchronous dynamo-electric machine or a permanent-magnet type reluctance motor, the combination of a pole and the number of slots can be set as ten poles, 15, or 45 slots. Moreover, the combination of a pole and the number of slots can be set as 12 poles, 18, or 54 slots, or it can be made the combination of 14 poles, 21, or 63 slots, and can also be made the combination of further 16 poles, 24, 36 and 60, or 72 slots.
[0021] The stator in which this invention has an armature coil again, and the cylinder-like rotator constituted by the rotor core which forms magnetic irregularity, the slit arranged in the direction in alignment with each magnetic pole shaft of said rotator -- or the combination of a predetermined pole and the number of slots by the fraction, although the number of slots for which is equipped with the permanent magnet held in a part of slit, and it is sufficient by **** and ** generates the momentary electromagnetic force of the oscillation mode of a low degree carrying out a sequential rotation -- balancing -- average -- low -- it is the permanent-magnet type reluctance motor set as what does not take out degree harmonic content, and the pole of said rotator is characterized by four poles and the number of slots of said stator being 18, 30, 42, 54, or 66.
[0022] If it is in such a permanent-magnet type reluctance motor, the combination of a pole and the number of slots can be set as six poles, 27 and 45, or 63 slots. Moreover, the combination of a pole and the number of slots can also be set as 12 poles, 27 and 45, or 63 slots. Furthermore, it can also be made the combination of 12 poles, 27 and 45, or 63 slots.
[0023] The stator in which this invention has an armature coil further, and the cylinder-like rotator constituted by the rotor core which forms magnetic irregularity, the slit arranged in the direction in alignment with each magnetic pole shaft of said rotator -- or the combination of a predetermined pole and the number of slots by the fraction, although the number of slots for which is equipped with the permanent magnet held in a part of slit, and it is sufficient by **** and ** generates the momentary electromagnetic force of the oscillation mode of a low degree It is the permanent-magnet type reluctance motor which set the secondary harmonic content which balances and affects an oscillation most by carrying out a sequential rotation as what is not taken out on the average. The pole of said rotator is characterized by eight poles and the number of slots of said stator being 18, 42, or 54.
[0024] If it is in such a permanent-magnet type reluctance motor, the combination of a pole and the number of slots can be set as ten poles, 12, 18, 42, 48, 54 and 66, or 72 slots. Moreover, the combination of a pole and the number of slots can also be set as 14 poles, 24, 30, 36, 48, 54 and 60, or 72 slots. Furthermore, it can also be made the combination of 16 poles, 30, 42 and 54, or 66 slots.
[0025]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained in full detail based on drawing. The structure of the common permanent-magnet type reluctance motor as a synchronous rotating machine is shown in drawing 1 and drawing 2 . The permanent-magnet type reluctance motor 1 consists of the stator 3 which has an armature coil 2, and the rotator 5 of the shape of a cylinder constituted by the rotor core 4 which forms magnetic irregularity.
[0026] a stator 3 -- the inside of a frame 6 -- many -- it is the structure which carried out the laminating of the stator core 7 of several sheets, held it, has arranged the iron core presser foot 8 to shaft-orientations both ends, and was united with them. And the slot 9 of a predetermined number was formed in the inner circumference side of a stator core 7, and the armature coil 2 is held in this slot 9.
[0027] a rotator 5 -- many -- the slit arranged in the direction which is the structure which carried out the laminating of the rotor core 4 of several sheets, and met each magnetic pole shaft of this rotator 5 -- or the magnetic irregularity of a circumferencial direction is formed by holding a permanent magnet 10 in a part of slit. 11 is a shaft, the center section of a rotator 5 strong-**, ends are supported by the frame 6 through bearings 12 and 13, and this frame 11 outputs the turning effort of a rotator 5.
[0028] The revolution property of the permanent-magnet type reluctance motor 1 of such mechanical structure is explained. Although the coil called the distribution volume which carried out the form of a rope is used in the induction motor, between the pole p of the rotator in this case, the number Ns of slots of a stator, and a source resultant pulse number m, the following relational expression has been recommended from the former.
[0029]
[Equation 1] Ns=mxpxq -- here, q is the number of slots for which it is sufficient by **** and **, and this is integrally made desirable [that it is larger than 1 or 1]. For example, if it is 4 pole three phase circuit (p= 4, m= 3), the number of slots is a multiple of 12 (=pxm), and 24 or 36 is made adequate several. If it is 24 throttles, the motor of eight poles will also be made as q= 1.
[0030] However, the relation of this oscillation and the reluctance motor of 8 pole 36 slot made as an experiment to noise cure verification is not drawn from a formula conventionally [this]. That is, in q= 1, it will become 24 slots (= 1x8x3), and will become 48 slots (= 2x8x3) in q= 2.

[0031] If this is in the permanent-magnet type reluctance motor 1, it is a fraction slot desirable for slot ripple reduction in addition to [of the number of slots and pole which had been set up with the conventional induction motor] proper, and shows that there is combination of the number of slots and pole which were moreover excellent also in pair vibratility.
[0032] As a result of analyzing the cure of the problem which arose with the 1st above-mentioned prototype, and the 2nd prototype which solved this trouble, the following thing became clear about solving an oscillation, a noise problem, and a slot ripple.
[0033] (1) An oscillation is based on electromagnetic force.
[0034] (2) Although it rotates applying the force a rotator 5 makes a stator 3 an anchorage and it is weak for reacting at this, especially in the reluctance motor which is giving the salient pole property to the rotator 5, concentrate on the location of a rotator pole and this torque occurs.
[0035] (3) Depending on how to apply this force, although a stator 3 takes the various oscillation modes, the description of that oscillation is said as follows.
[0036]
[A table 1]

振動モード

m1振動モード	むずれが起きたような動きの振動	1直径節振動	
m2振動モード	円形を両サイドの2点で押した際、楕円形状になるが、この動きの振動	2直径節振動	図3(a)
m3振動モード	円形を3点で押した際、おむすび形状になるが、この動きの振動	3直径節振動	図3(b)
m4振動モード	円形を4点で押した際、4角形になるが、この動きの振動	4直径節振動	図3(c)
:	:	:	:
mn振動モード	円形をn点で押した際、n角形になるが、この動きの振動	n直径節振動	図3(e)

(4) If the oscillation mode of a low degree not more than m2 oscillation mode is made from electromagnetic force so that the configuration of the movement toward an oscillation may also show, even if the value of the electromagnetic force is small, the stator 3 or frame 6 of a motor will be swayed simply. On the contrary, if it operates by the oscillation mode beyond m4 mode, a big oscillation will not become by the same electromagnetic force as the above, either. Although m3 oscillation mode is among above-mentioned both, it is more desirable to avoid, in order that an oscillation may remain in the same electromagnetic force.
[0037] (5) Although the number q of slots for which it is sufficient by **** and ** is conventionally made into the integer as mentioned above, pair vibratility becomes the factor to which it enlarges a slot ripple in the permanent-magnet type reluctance motor 1 even when this is good. In order to solve these, effectiveness is raised by what has a small motor capacity by twisting by the shaft orientations of body of revolution, taking structure (skew), and aiming at distribution of the electromagnetic force by the location. However, it is disadvantageous for manufacture to become complicated and to apply to the permanent-magnet type reluctance motor 1.
[0038] (6) The same effectiveness as having carried out the skew can be taken out with combination with suitable pole and number of slots.
[0039] Below, the reason is explained. Drawing 4 shows the relation between the location of **** in three-phase-circuit actuation, and a slot. If q is made into an integer, electromagnetic force will balance to the 2-way for every angle 180 degrees, and torque will generate it on the two poles (it is shown that all the slot configurations equivalent to a pole are the same configurations.). Since the number of slots between poles is a multiple of 3, the torque of m2 oscillation mode of a low degree in which generating of the torque which balanced is materialized occurs. This serves as m2 oscillation mode which repeats a circle and an ellipse, and will induce an oscillation on a stator 3 and a frame 6.
[0040] In 4 pole motor which makes q an integer, it balances in the four directions for every angle 90 degrees, and torque occurs (it is shown that all the slot configurations equivalent to a pole are the same configurations.). Although it becomes a circle and the oscillation mode of four square shapes and a stator 3 and a frame 6 are made to vibrate since generating of the torque which balanced since the number of slots between poles was a multiple of 3 is materialized, it becomes the mode dramatically strong against an oscillation. Since all torque has balanced in four directions, the torque of a low degree is not generated theoretically. For this reason, although there is no oscillating noise, since q is an integer, measures will be taken at all to the slot ripple.
[0041] In order to avoid this, except an above-mentioned skew, there is a method of taking the number q of slots per **** and **** to a fraction. That is, if torque distribution symmetrical with the line of four or more directions is secured to a rotator core by the fraction slot, a good result will be obtained also to a torque ripple also to an oscillation.
[0042] Drawing 5 shows the slot configuration over a pole like drawing 4 , and it is shown that all the slot configurations equivalent to a pole are the same configurations. If pole q=1+1/3, the slot configuration equivalent to a pole will become the same. Since the number of slots between poles is not a multiple of 3, magnetic flux which the excitation power source of a three phase circuit makes cannot be made equal, consequently it is impossible to expect the same torque as four directions, although the electromagnetic force in each pole seems to be the same apparently as for this.
[0043] However, if q=1+1/2, the slot configurations equivalent to a pole also differ and the same torque as four directions as well as the above-mentioned case cannot be expected.
[0044] Drawing 6 shows the case of 6 pole motor. The fundamental operation is the same as that of the case of the motor of drawing 4 and drawing 5 . That is, the slot configuration which is equivalent to a pole if q is taken for an integer becomes the same for every pole, and if the slot between poles is made into the multiple of 3, the same torque will occur in six directions, and this serves as m6 oscillation mode and serves as an oscillation shown in drawing 3 (d).
[0045] On the other hand, if q=1+1/2, the slot configuration equivalent to a pole will serve as m3 oscillation mode as it is illustrating, if it is the same as a short flight and remains as it is. Moreover, although the number of slots between

poles is not a multiple of 3, since the number of slots between one pole of a jump turns into a multiple of 3, the torque of P1, P3, and P5 becomes the same. Since it cannot say that the m3 mode is strong to an oscillation, this cannot be chosen as a suitable example.
[0046] Drawing 7 shows 8 pole motor. In the integer slot of q= 1, it becomes m8 oscillation mode like before. In q=1+1/2, since the slot configuration of the number of slots between poles which is the multiple of 3 and is equivalent to a pole is the same as that of a short flight, it becomes m4 oscillation mode with which the torque of the 4 directions balanced.
[0047] The combination of the pole and the number of slots which do not take out the oscillation mode of a low degree with a fraction slot theoretically only after become this 8 pole motor can be chosen now.
[0048] Thus, although the relation of the pole and the number of slots which do not generate the oscillation mode of a low degree theoretically about 4 pole motor, 6 pole motor, and 8 pole motor was verified based on drawing 4 - drawing 7 , it explains in more detail from a structure side.
[0049] (A) In the case of 4 pole permanent-magnet type reluctance motor, it is number Ns=mof slots (pole) xp(source resultant pulse number) xq=3x4xq of a stator in this case.
[0050] The number of slots regulated from the oscillation mode becomes a view of the torque of source resultant pulse number xqx (four symmetrical directions). That is, it is Ns=3xqx4.
[0051] The view of this formula can do the view that the same electromagnetic force occurs on each pole of four poles, if the slot of the same configuration exists by the multiple of three in the include angle of 90 degrees as shown in drawing 5 . in order for the slot configuration which is equivalent to a pole by the multiple of three to be the same in this include angle of 90 degrees -- q -- an integer -- ******** -- ******** . if it is made for 3xq to become an integer -- q -- an integer -- or (integer +1/3) (integer +2/3) it can take. however, () -- Ns is it no longer the multiple of 3 that it is an inner value, and each phase of the three phase circuit by the side of a stator becomes impossible to symmetry arrangement Moreover, unless the slot in 90 degrees is the multiple of 3, arrangement of the symmetrical repeat of a three phase circuit cannot be performed. Therefore, in the case of four poles, q cannot take a fraction slot.
[0052] (B) In the case of 6 pole permanent-magnet type reluctance motor, it is Ns=m(pole) xp(source resultant pulse number) xq=6x3xq in this case.
[0053] The number of slots regulated from the oscillation mode serves as torque of source resultant pulse number xqx (six symmetrical directions). That is, it is Ns=3xqx6.
[0054] In order, as for Ns, for the slot of the same configuration to be arranged by the multiple of 3 by the same view as the case of 4 pole motor on each pole at the symmetry, the need that the number of slots which exists in the include angle of 60 degrees is a multiple of 3 to q needs to be an integer.
[0055] However, it will be set to Ns=3x2qx3 if m3 oscillation mode is looked at. That is, the conditions of Ns will be fulfilled if 2q within a 120-degree angle is an integer. This means as q an integer or (integer +1/2) that it can take. However, the number of slots which generates this oscillation mode is made into the outside of selection.
[0056] (C) In the case of 8 pole permanent-magnet type reluctance motor, it is Ns=mxpxq=8x3xq in this case.
[0057] The number of slots regulated from the oscillation mode serves as torque of source resultant pulse number xqx (four symmetrical directions or eight directions). That is, it is Ns=3x2qx4 at the torque case of four directions. 2q needs to be an integer in order to arrange the multiple of 3, and the slot of the same configuration for this Ns on the two poles each at the symmetry. As q which fulfills this condition, an integer and the fraction slot of 1/2 can be taken.

[0058] Moreover, in the case of the torque of eight directions, it is Ns=3xqx8. In order to arrange this Ns on each pole at the symmetry, it needs to be [the multiple of 3 and the slot of q of the same configuration] integers.
[0059] As these results, when one half of fraction slots were chosen in the case of 8 pole motor, it was taken into consideration to the slot ripple and the oscillation. On the other hand, in the case of the integer, only the oscillation was taken into consideration.
[0060] (D) In the case of 10 pole permanent-magnet type reluctance motor, it is Ns=mxpxq=10x3xq in this case.
[0061] The number of slots regulated from the oscillation mode serves as torque of source resultant pulse number xqx (five symmetrical directions or ten directions). That is, in the case of five directions, it is set to Ns=3x2qx5. This Ns is the multiple of 3, and 2q needs to be an integer in order to arrange the slot of the same configuration on the two poles each at the symmetry. As q which fulfills this condition, q can take an integer and the fraction slot of 1/2.
[0062] Moreover, in the case of the torque of ten directions, it is Ns=3xqx10. This Ns is the multiple of 3, and q becomes an integer in order to arrange the slot of the same configuration on each pole at the symmetry.
[0063] (E) In the case of 12 pole permanent-magnet type reluctance motor, it is Ns=mxpxq=12x3xq in this case.
[0064] The number of slots regulated from the oscillation mode serves as torque of source resultant pulse number xqx (four symmetrical directions, six directions, or 12 directions). That is, in the case of four directions, it is set to Ns=3x3qx4. 3q needs to be an integer within the include angle of 90 degrees. as q which fulfills this condition -- an integer -- or (integer +1/3) (integer +2/3) it can take. However, in the case of six poles and 12 poles, if the number of slots is not a multiple of 9, the coil by the side of a stator may be unable to be arranged, and only an integer can be chosen from this constraint as q so that rotating magnetic field may be made.
[0065] Moreover, in the case of six directions, 2q needs to be an integer within the include angle of 60 degrees. In q which fulfills this condition, an integer and the fraction slot of (integer +1 / 2) can be taken.
[0066] In the case of further 12 directions, it is Ns=3xqx12. q needs to be an integer in order to arrange the slot of the same configuration for this Ns by the multiple of 3 on each pole at the symmetry.
[0067] (F) In the case of 14 pole permanent-magnet type reluctance motor, it is Ns=mxpxq=14x3xq in this case. The number of slots regulated from the oscillation mode serves as torque of Ns= source resultant pulse number xqx (seven symmetrical directions or 14 directions). That is, in the case of seven directions, it is Ns=3x2qx7. 2q needs to be an integer in order to arrange the slot of the same configuration for this Ns by the multiple of 3 on the two poles each at the symmetry. As q which fulfills this condition, the slot of an integer and the fraction of 1/2 can be taken.
[0068] On the other hand, in the case of 14 directions, it is Ns=3xqx14. This Ns is the multiple of 3, and q needs to be an integer in order to arrange the slot of the same configuration on each pole at the symmetry.
[0069] (G) In the case of 16 pole permanent-magnet type reluctance motor, it is Ns=mxpxq=16x3xq in this case. The number of slots regulated from the oscillation mode serves as torque of Ns= source resultant pulse number xqx (four symmetrical directions, eight directions, or 16 directions). That is, in the case of four directions, it is Ns=3x4qx4. 4q needs to be an integer in order to arrange the slot of the same configuration for this Ns by the multiple of 3 on the

two poles each at the symmetry. as this condition -- q -- an integer, 1/2, and (integer +1/4) -- or (integer +3/4) can take a fraction slot.
[0070] Moreover, in the case of eight directions, it is Ns=3x2qx8. 2q needs to be an integer in order to arrange the slot of the same configuration for this Ns by the multiple of 3 on the two poles each at the symmetry. As this condition, q can take an integer and the fraction slot of (integer +1 / 2).
[0071] In the case of further 16 directions, in order to arrange the slot of the same configuration for Ns by the multiple of 3 on each pole at the symmetry, q needs to take an integer.
[0072] By the above, the number of slots for which it is sufficient by **** and ** explained what the electromagnetic force of the oscillation mode of a low degree does not generate in the combination of a pole and the number of slots by the fraction.
[0073] however, the thing which the momentary electromagnetic force of the oscillation mode of a low degree is generated besides the combination of the pole and the number of slots which were mentioned above in the case of a permanent-magnet type reluctance motor, but is done for a sequential rotation -- balancing -- average -- low -- there is combination which does not take out degree harmonic content.
[0074] Moreover, the number of slots for which it is sufficient by **** and ** can balance by carrying out the sequential rotation of the combination of a predetermined pole and the number of slots by the fraction, although the momentary electromagnetic force of the oscillation mode of a low degree is generated, and the secondary harmonic content which affects an oscillation most can also be set as what is not taken out on the average.
[0075] a table 2 -- the behavior of the permanent-magnet type reluctance motor of the various combination of a pole and the number of slots -- simulating -- low -- the result of having evaluated the generating degree of degree higher harmonic is shown. In this table 2, the field component in the m2 mode of the valuation basis of O mark is 0 on the average. And a table 3 enumerated the suitable combination of a pole and the number of slots.
[0076] In addition, since imbalance will arise to the torque of the direction of an equal angle centering on a shaft, the amount of this imbalance will appear as torque of a low degree and an oscillation will be induced when adopting a fraction slot as q and the number of slots except having mentioned to the top table is chosen, it should avoid.
[0077]
[A table 2]

極数とスロット数に対する低次高調波の発生度合

	4極	6極	8極	10極	12極	14極	16極
6	○						
9	×		×				
12	○		○	○			
15	×		×	○			
18	○	○	○	○	○		
21	×		×	×		○	×
24	×		○	×		○	○
27	×	○	×	×	○	×	×
30	○		×	○		○	○
33	×		×	×		×	×
36	○	○	○	×	○	○	○
39	×		×	×		×	×
42	○		○	○		○	○
45	×	○	×	○	○	×	×
48	○		○	○		○	○
51	×		×	×		×	×
54	○	○	○	○	○	○	○
57	×		×	×		×	×
60	○		○	○		○	○
63	×	○	×	×	○	○	×
66	○		×	○		×	○
69	×		×	×		×	×
72	○	○	○	○	○	○	○

○ 低次高調波は発生しない　　× 多くの高調波が発生

[A table 3]

極数とスロット数の好適な組み合せの例

	整数スロット	分数スロット		
		グループ1	グループ2	グループ3
4極リラクタンスモータ	12, 24, 36, 48, 60, 72		18, 30, 42, 54, 66	
6極リラクタンスモータ	18, 36, 54, 72	12, 36, 60	27, 45, 63	
8極リラクタンスモータ	24, 48, 72	15, 15		18, 42, 54
10極リラクタンスモータ	30, 60, 54, 66	18, 54		12, 18, 42, 48, 54, 66, 72
12極リラクタンスモータ	36, 72		27, 45, 63	
14極リラクタンスモータ	42	21, 63		24, 30, 36, 48, 54, 60, 72
16極リラクタンスモータ	48	24, 36, 60, 72		30, 42, 54, 66
記事	低次調波振動モードは避けているので、これによる振動・騒音は発生しないが、トリクルプルが右記に比し多く、場合によってはスキュー構造が必要になる。	低次調波振動モードは裂けているので、これによる振動・騒音は発生しない事は左記同様であるが、分数スロットを選んでいるためトルクリプルが低く押さえられる。		

The permanent-magnet type reluctance motor 1 shown in <example> drawing 1 and drawing 2 is the thing of the rotator 5 of eight poles for rail cars, and the stator 3 with 36 slots. The result of the vibration analysis to this suitable reluctance motor and the reluctance motor of 8 pole 33 slot with the nonconformity mentioned above is shown in the table 4 list at drawing 8 and drawing 9 .

[0078]

[A table 4]

起磁力成分	8P成分	10P成分
含有比率(8P成分を100%としたときの比率)	100%	14%

A table 4 shows magnetomotive-force distribution of 33 slot stator. It turns out that many content ratios of the 10th component (10P component) to the 8th oscillating component (8P component) which is a fundamental-wave component are contained with 14%.

[0079] Although drawing 8 shows the synthetic magnetomotive force of the 8th component A and the 10th component B, it turns out that the secondary oscillation mode of a low degree has occurred from this drawing 8 . If the 10th component (10P component) B contains this for the 8th component (8P component) A, the part of magnetic-flux size (the sense of the magnetic flux of 10P and 8P is in agreement) and the part of magnetic-flux smallness (the sense of the magnetic flux of 10P and 8P is reverse) will occur, and the magnetic imbalance of 10P-8P=2P component will generate it as a result.

[0080] On the other hand, in the case of the permanent-magnet type reluctance motor of 8 pole 36 slot of the example of this invention, as shown in the vibration analysis result of drawing 9 , the magnetomotive-force distribution near a sine wave is shown, and it turns out that about 100% is the 8th fundamental-wave component.

[0081] In addition, although the permanent-magnet type reluctance motor belonging to a synchronous rotating machine was explained above, the technical thought of this invention is applicable also like the synchronous motor using the usual synchronous machine and permanent magnet using a synchronous field winding.

[0082]

[Effect of the Invention] making into a fraction the number of slots for which it is sufficient by **** and ** in the relation between the pole of a rotator, and the number of slots of a stator, and setting the combination of a pole and the number of slots as a suitable thing according to the synchronous rotating machine of invention of claim 1-6, as

mentioned above, -- low -- the oscillation of degree harmonic cannot be issued and a slot ripple can also be stopped small. Thereby, small lightweight-ization can plan a device, it is easy in manufacture and low-pricing can be attained.
[0083] Moreover, according to the permanent-magnet type reluctance motor of invention of claim 7-9, generate the momentary electromagnetic force of the oscillation mode of a low degree by making into a fraction the number of slots for which it is sufficient by **** and **, and setting the combination of a pole and the number of slots as a suitable thing, but carrying out a sequential rotation -- balancing -- average -- low -- degree harmonic content is not taken out, and a slot ripple can also be stopped small, small lightweight-ization can plan a device by this, it is easy in manufacture and low-pricing can be attained.
[0084] Furthermore, according to the permanent-magnet type reluctance motor of invention of claim 10-13, generate the momentary electromagnetic force of the oscillation mode of a low degree by making into a fraction the number of slots for which it is sufficient by **** and **, and making the combination of a pole and the number of slots suitable, but By carrying out a sequential rotation, it balances, and can avoid taking out the secondary harmonic content which affects an oscillation most on the average, and small lightweight-ization can plan a device, it is easy in manufacture and low-pricing can be attained.

[Translation done.]

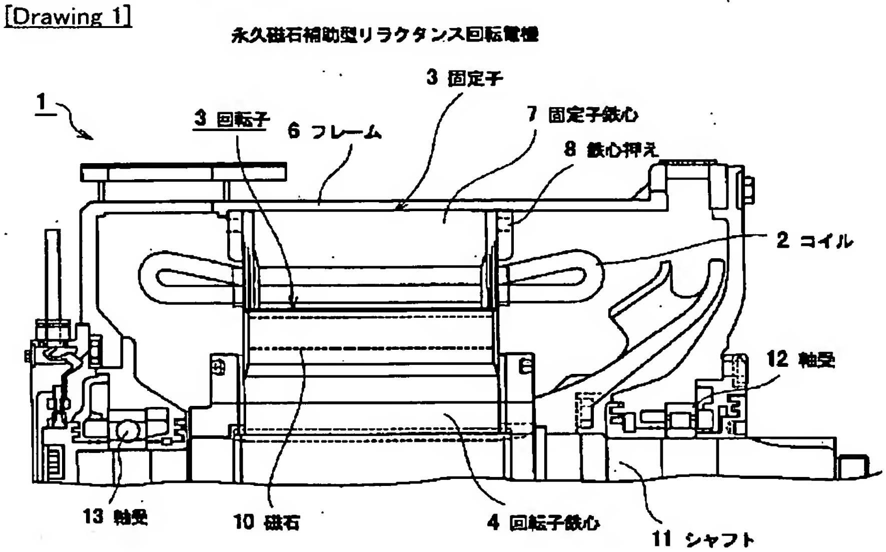
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The transverse-plane sectional view of the permanent-magnet type reluctance motor of the gestalt of one operation of this invention.
[Drawing 2] The side-face sectional view of the permanent-magnet type reluctance motor of the gestalt of the above-mentioned operation.
[Drawing 3] The explanatory view showing the oscillation mode generated in the various permanent-magnet type reluctance motors with which the combination of a pole and the number of slots differs.
[Drawing 4] The explanatory view showing the relation between the pole of 2 pole motor and 4 pole motor, and a slot.
[Drawing 5] The explanatory view showing the relation between the pole of 4 pole motor, and a slot.
[Drawing 6] The explanatory view showing the relation between the pole of 6 pole motor, and a slot.
[Drawing 7] The explanatory view showing the relation between the pole of 8 pole motor, and a slot. Torr distribution map.
[Drawing 8] The graph to which the synthetic magnetomotive force generated in the permanent-magnet type reluctance motor of 8 pole 33 slot was made to correspond with angle of rotation.
[Drawing 9] The graph to which the magnetomotive force of the permanent-magnet type reluctance motor of 8 pole 36 slot of the example of this invention was made to correspond with angle of rotation.
[Description of Notations]
1 Permanent-magnet Type Reluctance Motor
2 Coil
3 Stator
4 Rotor Core
5 Rotator
6 Frame
7 Stator Core
9 Slot
10 Magnet

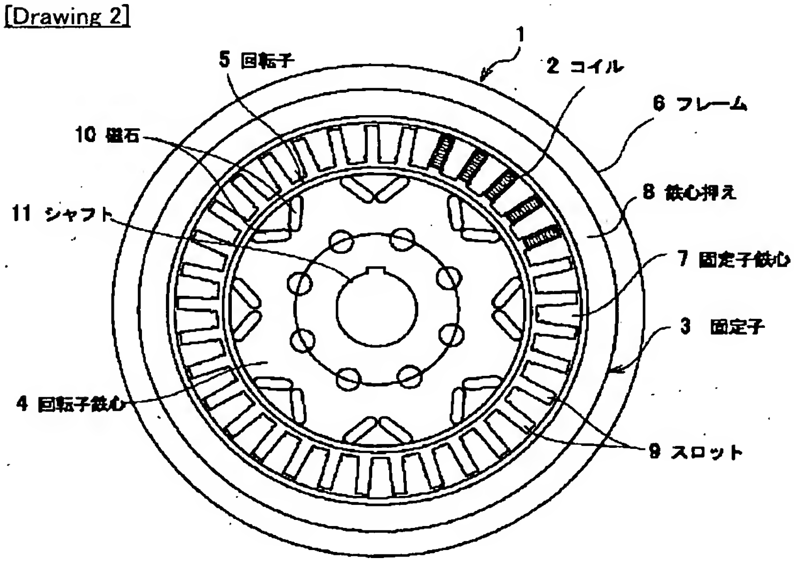
[Translation done.]

DRAWINGS

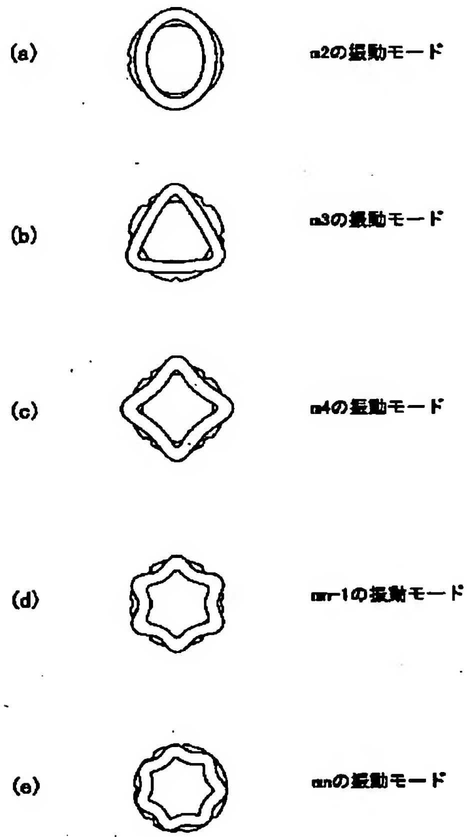
[Drawing 1]



[Drawing 2]

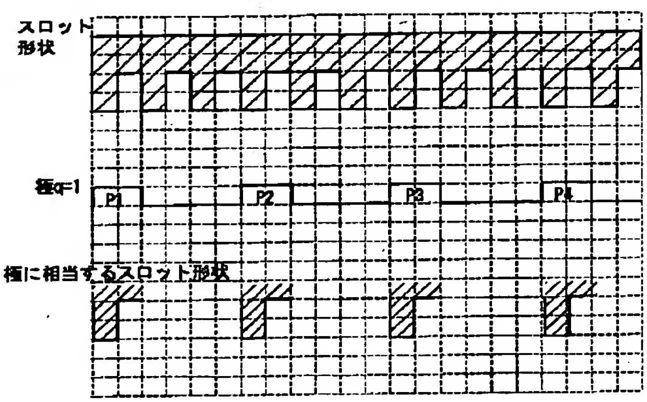


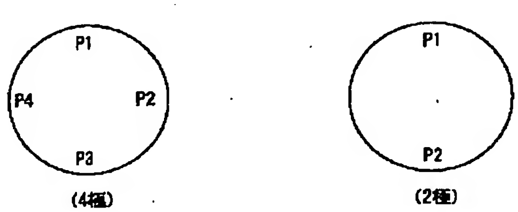
[Drawing 3]



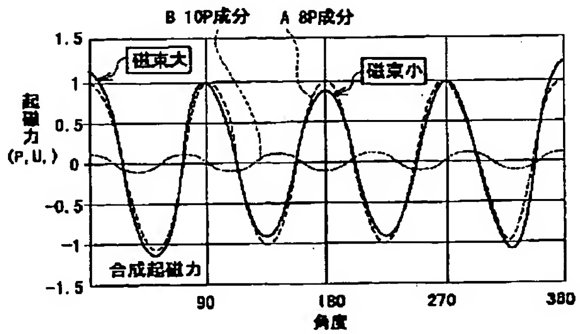
[Drawing 4]

2極、4極電動機の極とスロットの関係



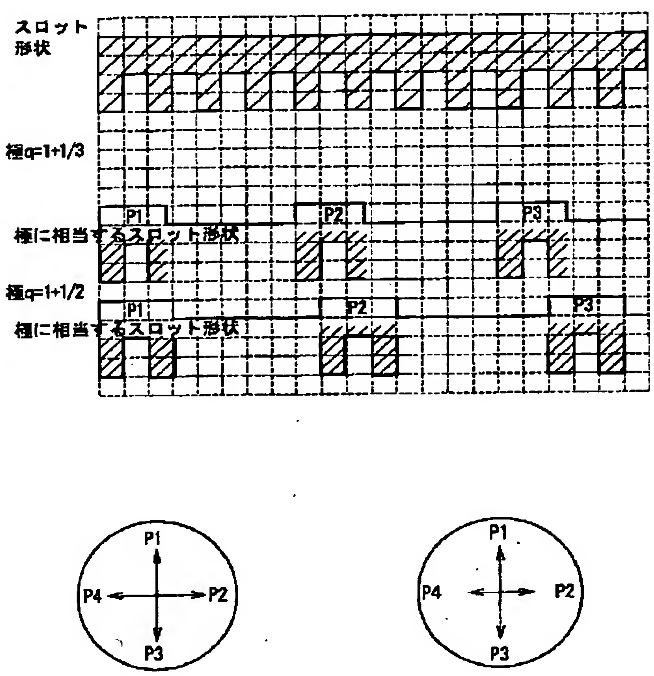


[Drawing 8]



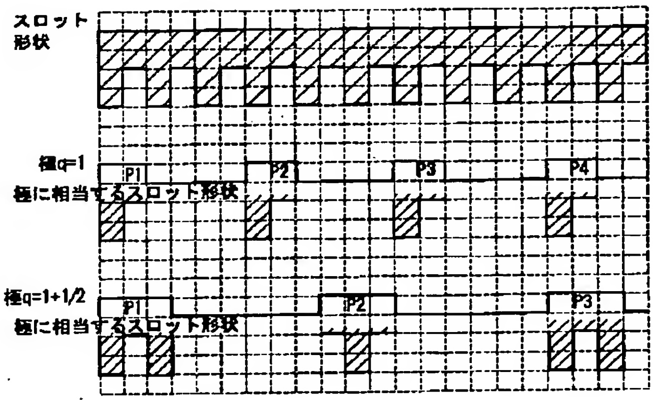
8P成分と10P成分の合成起磁力

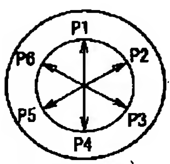
[Drawing 5]
4極電動機の極とスロットの関係



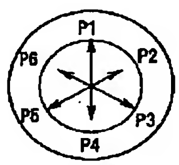
[Drawing 6]

6極電動機の極とスロットの関係





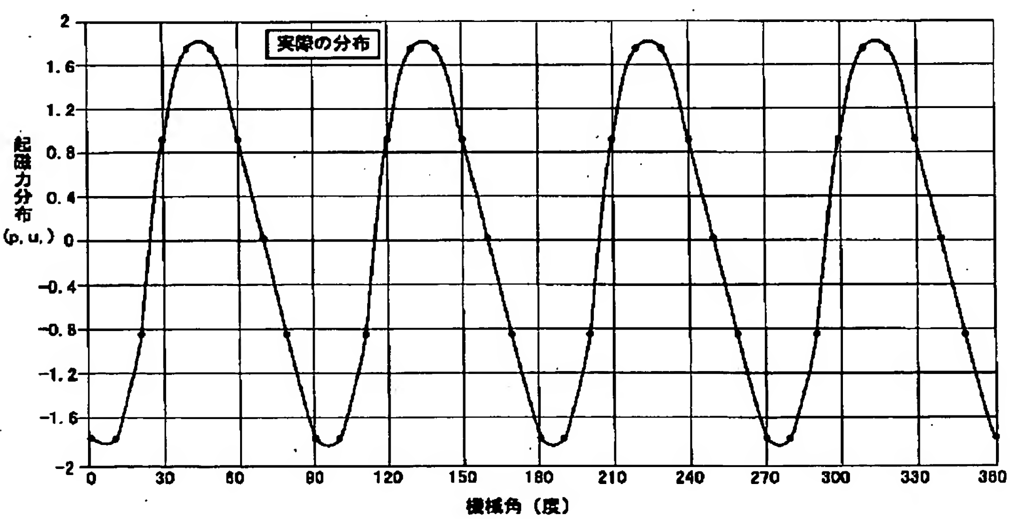
6極電動機
q=1



6極電動機
q=1+1/2

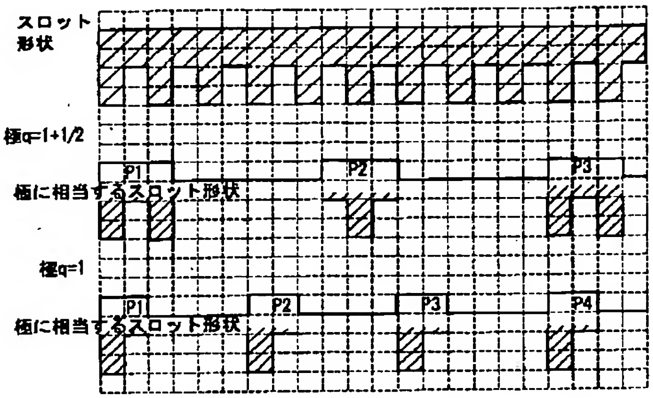
[Drawing 9]

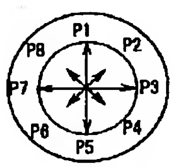
8P-36スロットモータ（実施例）の起磁力分布（但し、スロットリップル、磁石磁束は無視、t=0）



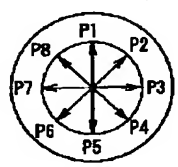
[Drawing 7]

8極電動機の極とスロットの関係





8極電動機
q=1+1/2



8極電動機
q=1

[Translation done.]